**Science Benchmark: 06 :03**

The solar system consists of planets, moons, and other smaller objects including asteroids and comets that orbit the sun. Planets in the solar system differ in terms of their distance from the sun, number of moons, size, composition, and ability to sustain life. Every object exerts gravitational force on every other object depending on the mass of the objects and the distance between them. The sun's gravitational pull holds Earth and other planets in orbit. Earth's gravitational force holds the moon in orbit.

**Standard 03:**

Students will understand the relationship and attributes of objects in the solar system.

**Objective 1:**

Describe and compare the components of the solar system.

Activity 1: Tour of the Solar System

Intended Learning Outcomes:

1-Use science process and thinking skills
3-Understand science concepts and principles
4-Communicate effectively using science language and reasoning
5-Demonstrate awareness of social and historical aspects of science
6-Understand the nature of science

Teacher Background:

In this activity students use research skills to learn about the components of the solar system. Although students should learn basic information about the solar system, the particular things they learn are not as important as the research process. Students will need access to a variety of resources including books, Internet, and NASA materials.

Materials:

- large cardstock letters that spell NINE PLANETS IN THE SOLAR SYSTEM
- video clip(s) from a space movie (such as *Star Wars, Armageddon, Apollo 13)* • images of the moon, the sun, planets, comets, asteroids, meteors, etc. Possible images could be "Solar System Lithograph Set for Space Science" (NASA LS-2001-08-002-HQ), NASA poster "Mapping the Solar System," offered through U.S. Geological Survey (I-2447 ) or Internet images arranged in a media presentation (see Additional Resources)
- "Hansen Planetarium Solar System Fact Sheet 2002," printed on card stock, at least one per student group (see Appendix) • student resources, including textbooks, trade books, NASA publications, and Internet access (see Additional Resources)
- large black surfaces for each group to display project (poster board, black craft paper, black garbage bag)
- drawings or photos of various spacecraft (see Additional Resources)

• graphing paper • classroom supplies: paper, markers, colored pencils, scissors, and glue
• worksheet "Notes on the Solar System"

**Invitation to Learn:**

Devise a quiz show like *Wheel of Fortune* using the term *Nine Planets in the Solar System* as the mystery phrase. Print one letter each on cardstock and arrange the cards face down in sequence on a wall or board in the classroom. Divide the class into two teams and have students turn over cards as they guess a correct letter. When they have uncovered the phrase, invite the students to find out more about the solar system.

Show a clip(s) from a movie such as *Star Wars, Armegeddon or Apollo 13,* etc. Select a scene that shows space travel or objects in space. Depending on the movie, invite students to speculate if the scene is possible? Discuss the following: Is it possible to visit other planets? Which planets? Will it be possible in the future? What are the planets like? Could there be life on other planets or moons in our solar system?

**Instructional Procedure:**

1. Divide students into teams of three to five and have each group brainstorm about what they already know and what questions they have about the solar system. Have each team record what they know on one side of a chart and make a list of their questions on the other side of the chart.

2. Meet as a whole class and have groups share information. If students have incorrect information turn it into a question to investigate. Record information and questions on a large class solar system chart. Together generate more questions about the solar system. You may want to make a third column to record answers to the questions at the end of the activity.

3. Introduce the major components of the solar system, including the planets, asteroids, and comets. If you desire, you may include major moons and rings of planets. Show images such as NASA solar system lithographs, "Mapping the Solar System" poster, video, transparencies, or books. Keep the information general and brief. Ask questions to generate interest and prompt the students to want to find out more. Examples: What caused these craters on Mercury? What is this wide scar across Mars?, etc. Record these questions on the class chart.

4. Use a method of your choice to place students in research teams of 2 to 4 people. Assign each team an object such as a planet, the moon, comets, asteroids, etc. in the solar system.

Optionally, you may also assign students the moons and rings of planets.

5. Assign groups to make displays that include particular tasks to complete. The tasks should be possible to complete with your particular set of research materials. The tasks listed in this activity are chosen because they help teach the core standard. You may want to choose additional tasks for your students to complete.

Assign the following activities:

• Make a chart highlighting the team's solar system object and its position from the sun. Note: Be sure that students understand that this is not a scale model and that planets are not lined up in a straight line.

• Make a model of the object to scale with the objects assigned to other groups. Size is assigned so that the scale model size listed coordinates with the “How Big, How Far” activity for Standard IV, Objective 1. Note: Use the measurements below for solar system size. In this scale the larger moons in the solar system will be about .5-.7cm. Asteroids, and comets will be .1cm or less. Alternately, students may calculate the correct sizes themselves. They may also include scale models of moons, if any. If you prefer you may use a different scale for the models. (See Additional Resources for a web site that calculates scale.)

**Scale Diameter of Planets**

| Mercury Venus Earth Mars Jupiter Saturn Uranus Neptune Pluto .8 2.0 2.1 1.1 23.5 19.8 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 8.4 8.2 .4<br>cm cm cm c.m. cm cm cm cm cm | | | | | | | | |

• Make four graphs showing the following:
Relative size of planets
Relative distance in kilometers or miles, light time, or astronomical units
Gravitational force of planets compared to gravity of earth or a comparison of how much something would weight on different planets One free choice graph

• Have students use the “Hansen Planetarium Fact Sheet 2002” as a resource for graphing data. They may also use the Exploratorium Internet site that calculates weight on different planets (See Additional Resources).

• Create travel brochures, posters, postcards, or other written material to illustrate and describe physical properties of the object, including size compared to the Earth, whether it is a solid or gas planet, its gravity compared to the Earth, and other interesting, unique physical features and facts.

• Make a time line showing historical information about this object. Major findings from space missions connected with this object should be included. Use current trade books, NASA resources, and Internet sites for resources. (See Additional Resource for suggestions.)

6. Allow students time for research. They should use multiple sources of printed material and Internet sources to research and gather information about their object. Resources you may want to use are listed at the end of the activity.

7. The student teams prepare a display and present their research to the rest of the class. Projects may be displayed on black poster board, large pieces of black craft paper, or large black garbage

bags. You may want students to make their display interactive by having something for observers to do. For example, they may have a matching game, lift up tabs, a spinning wheel, or an "answer-the-question" contest.

8. Students are now ready to "tour" the solar system. Organize the class for the tour. Have students take notes either on the "Notes on the Solar System" chart or in their science journals as they go from one display to the next.

9. In a class discussion refer to the original class chart where knowledge and questions were recorded. Check to make sure knowledge is correct. Check to see if answers to the questions were found. Record them in the chart. Discuss with students questions such as: What did you learn? What surprised you? What do you think you will remember? What is the mostimportant thing you learned? What do you still want to find out? Are there any questions for which scientists do not yet have answers?

**Possible Extensions/Adaptations/Integration:**

1. Focus this activity on the question: "Is there life somewhere else in the solar system?" As students go from one group display to the next in a "tour" of the solar system, have them answer questions about surface, the possibility of liquid water, the gravitational force, atmosphere, and amount of energy received from the sun. These topics could be on a chart similar to the "Notes on the Solar System" chart. For more ideas about this topic see the GEMS teacher's guide *Messages from Space*. It is built around the question, "Is there life out there?" (See Additional Resources)

2. Have each team create questions about important facts about the planet and display them at the bottom of their display. Compile (you also may have to revise) them for a class quiz. Have teams review the quiz questions at the end of the presentation.

3. Have an Astronomy Night where parents visit to take the "Tour of the Solar System." You may want to arrange a star party for the same night and integrate the other activities in the Astronomy standards.

Language Arts:

1. Teach lessons in writing such as organization, ideas, voice, and layout as students create brochures, postcards, or posters.

2. Teach reading skills to find the main idea and connect it with note taking and question writing as students use the astronomy reference books.

3. Teach students reading skills for using nonfiction text structures.

4. Collect travel brochures from various places from around the country or world. Use them to teach students how to write and lay out materials for their displays.

Math:

1. Teach graphing skills as students make graphs for the display.

2. Have students calculate the correct size of the scale models for their planets.

**Assessment Suggestions:**

1. Again show a clip(s) from a movie such as *Star Wars, Armageddon, Apollo 13,* etc., as you did in the Invitation to Learn. Have students evaluate whether the scene is possible on an other planet or object in our solar system. You may want to select scenes that show both realistic and unrealistic space travel, or scenes that show both possible and impossible physical settings.

2. Students write a persuasive essay about whether they think there is life in the solar system any place besides Earth.

3. Students compile questions for a spacecraft to investigate as it visits a planet(s). The quality of the questions will reflect understanding about the solar system.

**Additional Resources:**

http://astrogeology/usgs.gov
This quality web site has information and images about the objects in the solar system. The "Mapping the Solar System" poster can be ordered from this site for $7.00 plus shipping. It also has good links to other astronomy web sites.

http://www.exploratorium.edu/ronh/solar_system/index.html
This web site assists you and your students in making a solar system to the correct scale. You just enter a size for the sun and it computes the correct sizes and distances for the model.

http://www.exploratorium.edu/ronh/weight/index.html
This web site will calculate the weight of an object on each planet.

http://www.nineplanets
This web site has everything about the planets, history, mythology, scientific knowledge, lots of images, and even sounds and movies. An excellent student resource.

http://solarsystem.nasa.gov/
This web site's focus is Solar System Exploration. It features links to the planets and a history of exploration. It is frequently updated with upcoming events and latest images. An excellent student resource.

http://school.discovery.com/lessonplans/heavensabove/index/html
This page describes a lesson plan called Planetary Profiles. It would be a good extension for the "Tour of the Solar System" activity. School.discovery.com has other lesson plans on Astronomy. It also has useful links.

http://spacelink.nasa.gov/index.html/ This is another good NASA site. It includes a search function.

Teacher Guides:
Beals, Kevin, John Erickson, Cary Sneider. 2000. *Messages from Space: The Solar System and Beyond,* GEMS, Lawrence Hall of Science. An excellent resource is the GEMS teacher's guide *Messages from Space: The Solar System and Beyond*.

*Moons of Jupiter*. GEMS, Lawrence Hall of Science. This guide includes engaging activities about the four largest Jovian moons, including a simulation of Galileo's original observations. A set of 20 slides is included. Although the moons of other planets are not specifically mentioned in the core, the activities in this guide will enrich the students' understanding of the solar system.

<u>Student Printed Resources:</u>

There are countless children's books about astronomy and space. This list is not meant to be inclusive, but to show just a sample of what is available. As you choose books, select those that are accurate and current, have photos and graphics, and have a range of reading levels. You will want both books that cover general astronomy topics and those about specific topics.

Bonar, Samantha. *Asteroids*. 1999.

General information about asteriods. Pictures and photos, text covering about half the space, 64 pages.

Challoner, Jack. *The Atlas of Space*. 2001.

Large format, covers topics of solar system, deep space, and space exploration. A good overview, double pages for each planet, packed with information, plenty of illustrations. 80 pages, paperback. ($12.95)

Dickinson, Terence. *Other Worlds*. 1995.

Good information about all the planets, their moons, and other objects in the solar system. Photos and drawings, about half the pages are text, 64 pages. $9.95

The Galaxy

This is a set of 10 books about each of the planets and the sun. The books are straightforward with simple, basic information. Pages are organized with a picture on one side and three or four paragraphs on the other side with information about such topics as atmosphere, revolution and rotation, moons, space probes, etc. The books have 24 pages and are written on a 3rd to 4th grade level. The set includes a Teacher's Resource Book and is available in paperback from Capstone Publishers (www.capstone-press.com) ($56.95). They are also available in hard back from Amazon.com ($18.60, each).

Individual Titles:

Kipp, Steven L., *Mercury, Venus, Earth, Mars*

Vogt, Gregory L., *Sun, Jupiter, Saturn, Uranus, Neptune, Pluto*

Hawkes, Nigel. *The New Book of Mars*. 1998
Large format many illustrations. Good discussion of Mars space missions. 32 pages, hardbound. ($16.00)

Ride, Sally & Tom O'Shaughnessy. *The Mystery of Mars*. 1999.
Detailed description of features and conditions on Mars. Large colored drawings and photo graphs, text covering about half the space, 48 pages.

Simon, Seymour
Individual books on individual planets, sun galaxies, and comets, meteors, and asteriods. Basic information written with interesting comparisons and questions, square format, 32 pages, large color photographs. Available in paperback for $6.95. Look up by name of planet.

*Solar System*. Kids Discover Magazine. 2000.
This 16 page magazine includes photos, drawings, diagrams of the planets interspersed among short paragraphs of information. Back issues are available in quantity from the publisher 20+ at $2.50 each. Phone (212) 677-4457. Astronomy issues include *Solar System, Space, Galaxies, Astronauts, Mars, and Moon*.

Spangenburg, Ray. *A Look at Jupiter*. 2000. (and others)
This book is one of several about the solar system and space missions in a series called Out of This World. The books are more in depth than many books for children. They are
especially helpful for students reading at higher levels. They have 112 pages, with many color photos and detailed scientific information. Titles in the series include *A Look at Mars, A Look at Moons, A Look at Saturn, A Look at Venus*. There are several books about NASA space projects also. Available in paperback for $14.95.

**My Notes on the Solar System**

| | Size compared to Earth | Gas or Solid? | Gravity compared to Earth | Unique Physical Features |
|---|---|---|---|---|
| Mercury | | | | |
| Venus | | | | |
| Mars | | | | |
| Jupiter | | | | |
| Saturn | | | | |
| Uranus | | | | |
| Neptune | | | | |
| Pluto | | | | |
| Comets | | | | |
| Meteors | | | | |
| Asteroids | | | | |

**Science Benchmark: 06 :03**
The solar system consists of planets, moons, and other smaller objects including asteroids and comets that orbit the sun. Planets in the solar system differ in terms of their distance from the sun, number of moons, size, composition, and ability to sustain life. Every object exerts gravitational force on every other object depending on the mass of the objects and the distance between them. The sun's graviational pull holds Earth and other planets in orbit. Earth's graviational force holds the moon in orbit.

**Standard 03:**
Students will understand the relationship and attributes of objects in the solar system.

**Objective 2:**
Describe the use of technology to observe objects in the solar system and relate this to science's understanding of the solar system.

**Activity 2: Following in Galileo's Footsteps**

**Intended Learning Outcomes:**
1-Use science process and thinking skills.
2-Manifest scientific attitudes and interests

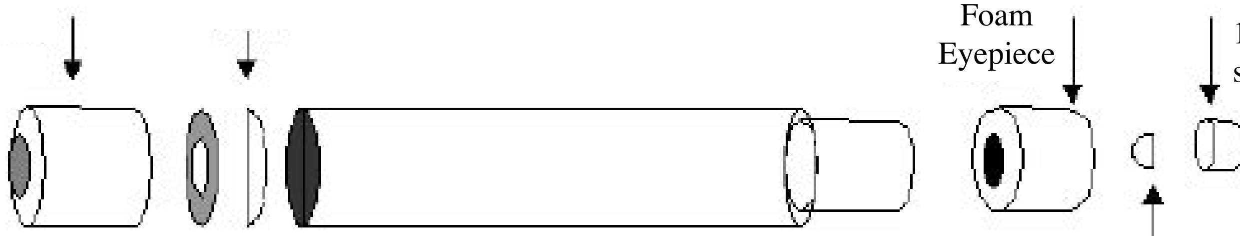
**Teacher Background:**
For centuries the only way the sky could be viewed was with the naked eye. Then in the sixteenth century the telescope was invented. One of the early telescope inventors, Galileo Galilei observed the four large moons of Jupiter. He kept meticulous records of the moon's changing positions and came to the conclusion that they actually orbited the planet, contra- dicting the notion that all objects orbited Earth as center of the universe. His observations lead to a whole new way of understanding the Earth and its place in the universe.

**Materials:**
- Poster or other visual of one or more of the moons of Jupiter
- Binoculars or other assorted telescopes
- Telescope kits, at least one per four-student team, been developed by Project Star, available from Learning Technologies, 40 Cameron Avenue, Somerville, MA 02144, 800-537-8703 ($4.50 each in sets of 10)

or
- Two paper towel tubes or mailing tubes, one 43 mm (about a 1 3/4") objective lens, one 17.5 mm (about 3/4") ocular lens, foam rubber cut in a cylinder the size of paper towel tube opening

**Invitation to Learn:**

**Cardboard Tube Telescope**




Show a poster or other visual of one or more of the moons of Jupiter, covering any identify ing labels. Ask students to identify it (them). Tell story of how Galileo observed the moons of Jupiter.

Show a slide of Galileo's journal page (see appendix *Moons of Jupiter*) Ask students to speculate what it is. Explain that it is a journal page from a great scientist, Galileo. Ask: What do you think he was recording? Tell the story of how Galileo observed the moons of Jupiter.

**<u>Instructional Procedure:</u>**

This activity uses either a simple telescope made with interlocking cardboard tubes and two simple lenses, binoculars or available telescopes. A convenient, inexpensive telescope is available from Learning Technologies (see materials). Or alternately make telescopes using two paper towel tubes in which one fits within the other, an object lens attached to the end opening on the outer tube, and an eyepiece lens, or ocular, attached at opposite end of inner tube.

1. Make telescopes with students or arrange for binoculars or assorted telescopes. You may have students draw a plan as shown in the materials section for making the telescope in their journals.

2. Allow students opportunities to experiment with the telescopes. Have them record observations in their journals. Challenge students by asking questions. How does the image appear in the telescope? How far can you see? How are objects in the distance changed? What problem do you have with the telescope? Can you solve them? (Images are hard to steady and you may consider how to rest them to help solve this problem.) You may want to go into more depth about refraction of light and consider coordinating activities from Standard VI, Objective 2.
3. The following activities will require using the telescopes at night. They could be checked out, used at a star party, or in an outdoor school setting. You will need to do a little home work to be sure of the visibility of the objects. Have students find the following objects and record a drawing and basic facts in their journals.

• <u>The moon.</u> The best time to view is near its crescent or quarter phases because shadows make craters more visible than during a full moon.

- Jupiter. Obviously it must be available to see and you will need to find its location. Students can look for small moons, bands on planet, etc.
- The Pleiades. This is a cluster of stars found in the shoulder of the constellation Taurus, the Bull. On a clear night it is easy to see with the naked eye, but more distinct stars are visible with the telescope.
- Double star Mizar and Alcor. The second star from the end of the handle of the Big Dipper is actually a double star. Mizar is the brighter.
- Great Nebula in Orion, the Hunter. Locate the belt in Orion and then the three stars hang as the sword. The end star at the tip of the sword is actually the Great Nebula.

**Assessment Suggestions:**

1. Students compare Galileo's use of the telescope with their own and compare with today's technology for learning about space.

2. Evaluate student journal entries. Look for organization, clarity and personal reflections.

**Additional Resources:**

*Moons of Jupiter.* GEMS, Lawrence Hall of Science. This guide includes engaging activities about the four largest Jovian moons, including a simulation of Galileo's original observations. A set of 20 slides is included. A copy of a page from Galileo's journal is included.

**Science Benchmark: 06 :03**

The solar system consists of planets, moons, and other smaller objects including asteroids and comets that orbit the sun. Planets in the solar system differ in terms of their distance from the sun, number of moons, size, composition, and ability to sustain life. Every object exerts gravitational force on every other object depending on the mass of the objects and the distance between them. The sun's graviational pull holds Earth and other planets in orbit. Earth's graviational force holds the moon in orbit.

**Standard 03:**

Students will understand the relationship and attributes of objects in the solar system.

**Objective 2:**

Describe the use of technology to observe objects in the solar system and relate this to science's understanding of the solar system.

Activity 3: Probes to Other Planets

Intended Learning Outcomes:

1-Use science process and thinking skills
2-Manifest scientific attitudes and interests
3-Understand science concepts and principles
4-Communicate effectively using science language and reasoning
5-Demonstrate awareness of social and historical aspects of science
6-Understand the nature of science

Teacher Background:

Technology is used in many ways to observe and explore the solar system and beyond. Some instruments allow us to perceive things that cannot be detected by human senses, such as portions of the electromagnetic spectrum (e.g., infrared, ultraviolet, etc.) invisible to human eyes. Technology, in the form of spacecraft robots, permits us to vicariously explore in the remote and hostile environment that characterizes the solar system. Because of the vast distances within the solar system, the time required to send instructions to or receive messages from these spacecraft ranges from a few minutes to several hours. So, pre-programmed computers play a vital role in controlling the actions of these spacecraft. Computers also assist in performing the tedious calculations required to predict the motions of both these spacecraft and the planets that they are sent to explore. Just as computers are now a part of many things in everyday life, such as automobiles, washing machines, etc., computers also play small and large roles in scientists' efforts to understand the solar system. For example, computers are used to help point telescopes or other instruments correctly, and are used to process images or other data.

Cassini–Huygens is a robotic space mission sent to explore Saturn and its moons. It was launched in October 1997 and is scheduled to arrive at Saturn in July 2004. (Details of this mission can be found at: http://saturn.jpl.nasa.gov/cassini/index.shtml)

This spacecraft will serve as an example to help students understand how technology is used to explore the solar system.

Materials:

- Spacecraft Components Sheet
- Cassini Component Functions Table
- overhead of Cassini: A Robot in Our Own Image
- materials such as egg cartons, yogurt containers, film canisters, parts of childrens' toys, toilet paper tubes, etc.
- construction paper
- aluminum foil
- wire

Invitation to Learn:

Ask students to define a robot. Ask what robots might do in space and what capabilities they might have.

Instructional Procedures:

1. Have students cut out parts of Cassini Robot from sheets of paper and assemble on another paper. They can glue them down when finished.
2. Have students volunteer to explain why they put the parts of the robot in the locations they chose.
3. Handout the Cassini Component Functions Table and give students time to fill in the human anatomy column.
4. Show students overhead made from Cassini: A Robot in our Own Image. Discuss student robot configurations and their answers to the Functions Table.
5. Arrange students in groups and present the task: To construct a robot spacecraft to explore a location in the Saturn System.
6. Student groups should first present the conditions they will encounter when they land. Will the spacecraft land on the surface of a moon or establish an orbit? Will it fly over or through rings? Will there be an atmosphere?
7. Student groups should design and build models of their spacecraft from the assortment of objects you provide or they bring from home. The model robot should have all the components to fulfill critical functions. The components do not need to be functional.
8. Students should present their robotic spacecraft models to the class. Each group member should explain a component.

**Assessment Suggestion:**

1. Student spacecrafts should include a framework, motors, antennas, computers, and a scientific instrument such as a camera or dust analyzer.
2. All students in the presentation are familiar with the functions of the parts on their spacecrafts.

**Possible Extensions/Adaptations/Integration:**

The activity can be downloaded from the activity page of Solar System Educators Program (SSEP) website at:

http://www.ssep.org/orbits/activities.html

The activity is in pdf format. Acrobat Reader is needed to open the activity. The web page has a link to download Acrobat Reader if you do not have it. (Ignore the Student Worksheet on page 12-5).

Three other activities on the of Solar System Educators Program (SSEP) web site can serve as extensions.

- “Which Way Should I Point?” is a short activity that reinforces some parts of the Cassini Robot and helps students understand problems in planning and carrying out observations.
- “Returning Pictures From Space” and “Speaking in Phases” are activities that help students understand how spacecrafts communicate with Earth.

**Additional Resources:**

Berger, Melvin and Gilda. *Can You Hear a Shout in Space*. 2000.
Engaging information about space exploration. Question and answer format, drawings and photographs, text on facing pages, 48 pages.

Gustafson, John. *Voyager: An Adventure Through Space*. 1994
A description of the Voyager space mission. Photos, drawings, interspersed with short paragraphs, 32 pages. (Scholastic)

Johnstone, Michael. *The History News: In Space*. 1999
Chronicles history of astronomy from A.D. 145 through current space explorations. Written in a newspaper format, illustrated with drawing and photos, 6th grade reading level. $6.99 in paperback.

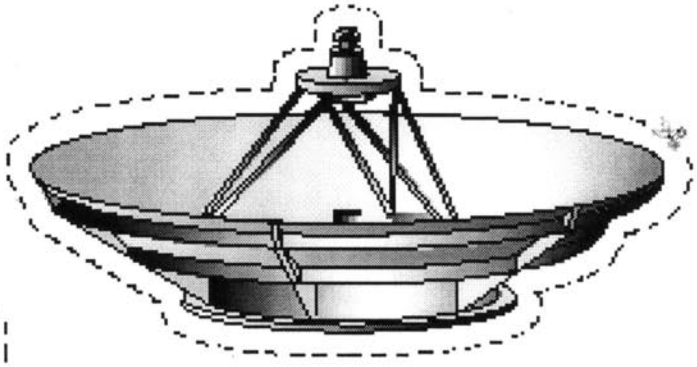
Scott, Elaine. *Close Encounters: Exploring the Universe with the Hubble Space Telescope*. 1998. A look at how the Hubble has broadened our knowledge of space, both near images and distant images, including star birth and death. Large color photos and text coverning about half the space, 64 pages. (Scholastic)

Gustafson, John. *Voyager: An Adventure Through Space*. 1994.
A description of the Voyager space mission. Photos, drawings, interspersed with short paragraphs, 32 pages. (Scholastic)

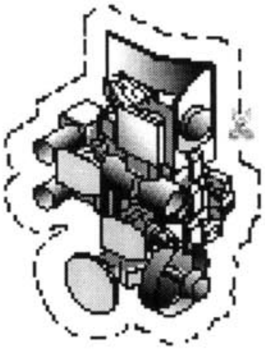
Skurzynski, Gloria. *Discover Mars*. 2000.
History of how man has learned about Mars, including Mariner, Viking I and II, and Path finder missions, and future plans. Large colored drawings and photos interspersed with short paragraphs, 48 pages. Comes with 3-D glasses for fun. (Scholastic)

Wunsch, Susi Trautmann. The Adventures of Sojourner. 1998.
Chronicles the Sojourner mission to Mars. About 2/3 text and 1/3 photos, 64 pages.

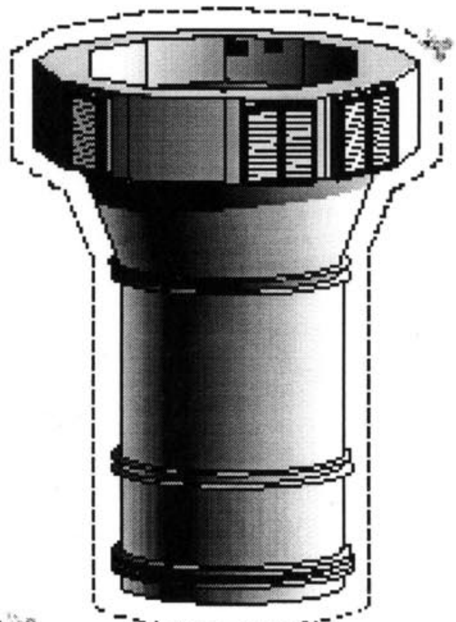
## Spacecraft Components



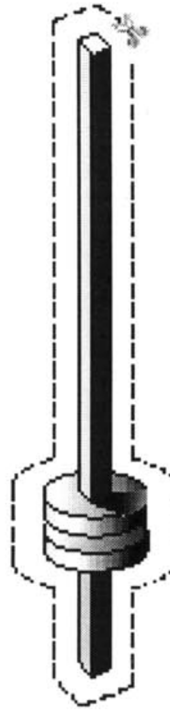
High/Low Gain Antennas



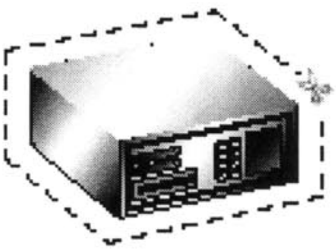
Camera



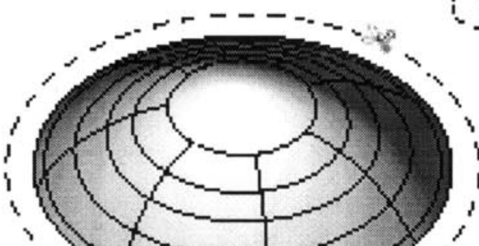
Main Core
Structure



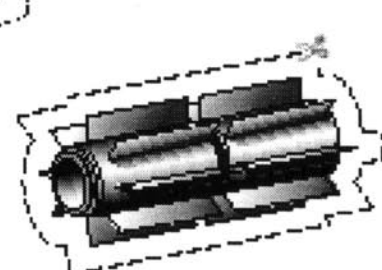
Magnetometer



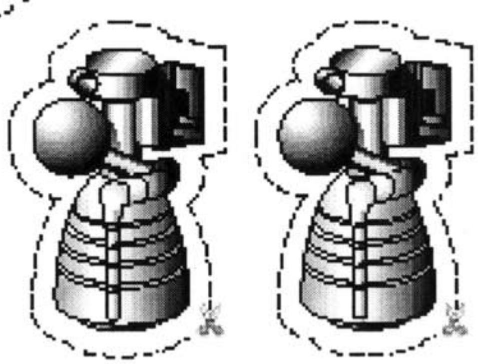
Computer



Atmospheric Probe



RTG Power Unit



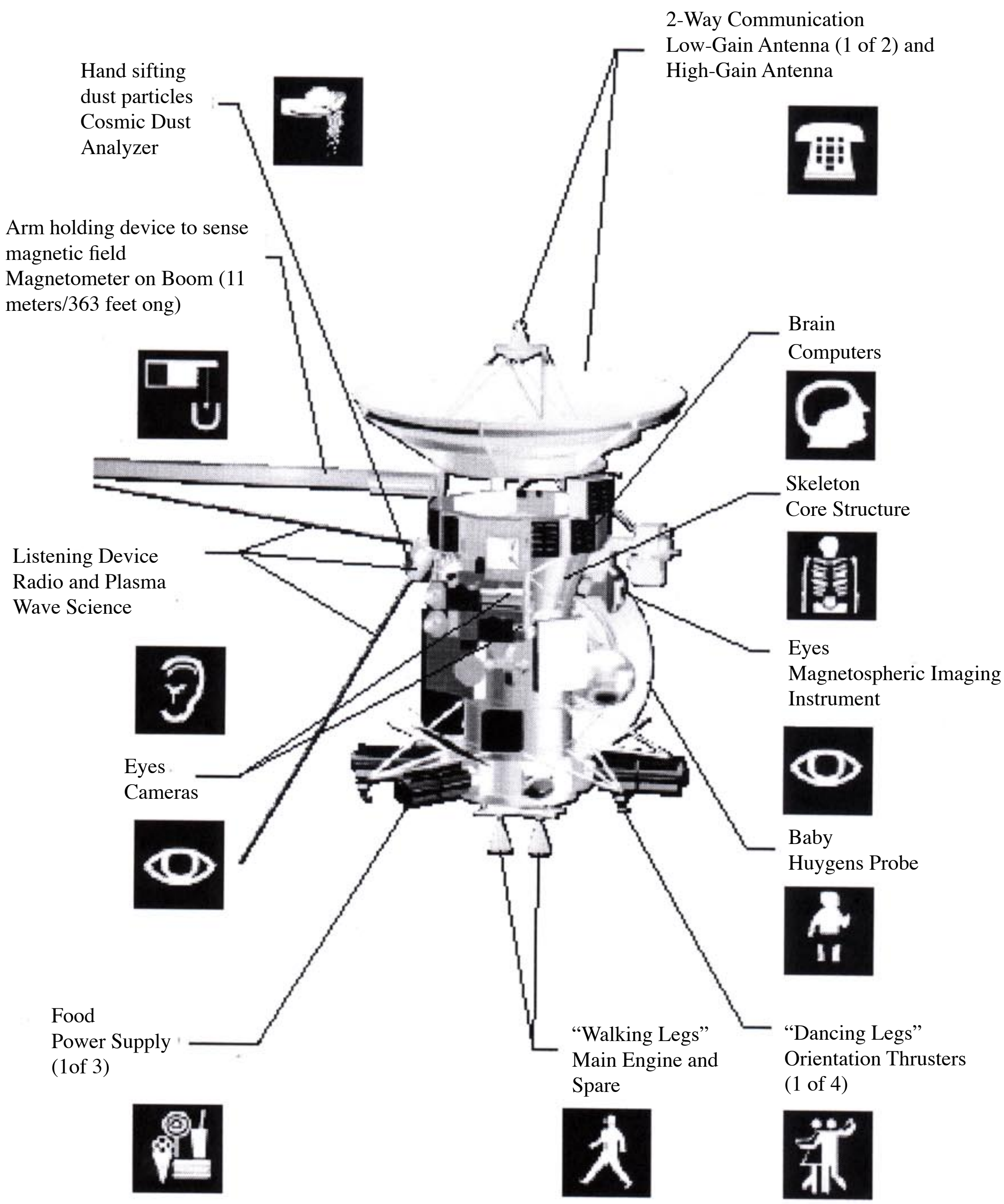
Main Engine
and Spare

## Cassini Component Function Table for Student Use

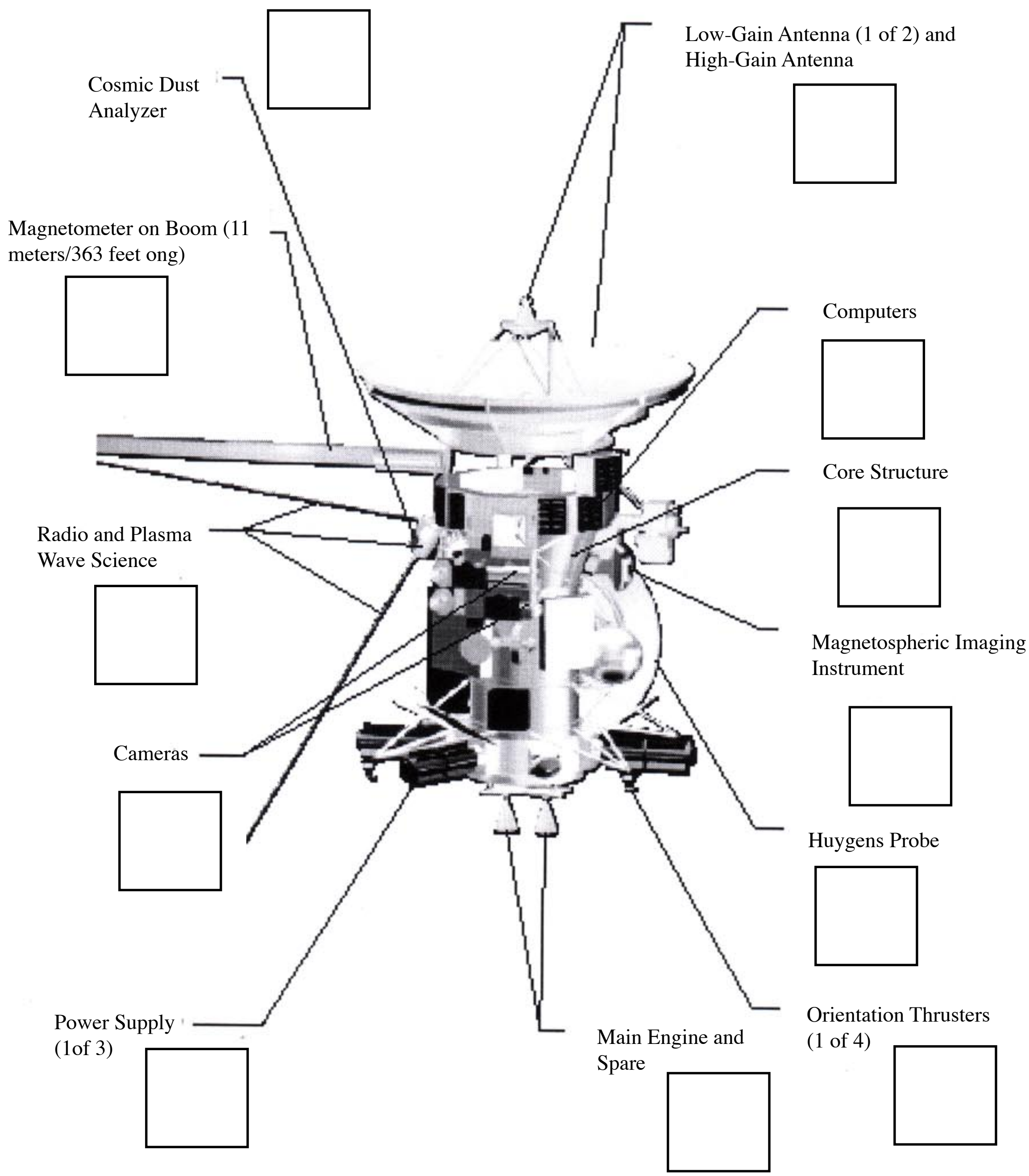
*Directions: Use the descriptions in the column labeled "function" to determine a possible human analogy for each Cassini component. Write your human part(s) or human need (s) in the blank column at the right.*

| Cassini Component | Function | Human Analogy |
|---|---|---|
| Spacecraft Bus | The bus is the core structure (or framework) to which spacecraft components are attached. The bus made out of aluminum; the same metal used in softdrink cans. | |
| Orientation Thrusters | These are small rocket thrusters (not the main engines) that are used for delicate maneuvers that rotate the spacecraft. This is useful for aiming instruments and pointing the antennae toward Earth | |
| Main Engines | Rocket motors provide thrust for moving the spacecraft in a particular direction or for braking maneuvers. | |
| RTG's | Radioisotope Thermoelectric Generators (RTG's) are the sources of energy for Cassini's instruments and transmitters. RTGs convert nuclear energy to electrical energy. RTG's are not used for propulsion. | |
| Spacecraft Cameras | Cameras and other science instruments "see" radio waves, infrared, visible, and ultra violet light emitted or reflected by Saturn and its rings and moons. | |
| RPW's | The Radio and Plasma Wave science instrument "listens" to different aspects of the environment around Cassini. | |
| Cosmic Dust Analyzer | The dust analyzer will sense dust particles that come into direct contact with the instrument. | |
| Magnetometer Boom | This is an 11-meter-long "arm" extending from the spacecraft. There are instruments in the middle and on the end the arm it that are used to detect and measure magnetic fields. | |
| High/Low Gain Antennae | Receivers and transmitters are used for communication between the spacecraft and Earth-based controllers. The antennae "hear" and "speak" for the spacecraft. | |
| Computers | Computers manage a variety of intelligent functions such as navigation and propulsion, storing information from scientific instruments, and sending information to Earth. There are over 40 different computers on Cassini. | |
| Huygens Probe | This probe will be released from the "mother" spacecraft probe to descent through Titan's atmosphere to gather data on this mysterious moon of Saturn. | |

# Cassini: A Robot in our Own Image - for Teacher Use



# Cassini: A Robot in our Own Image - for Student Use



## Cassini Component Function Table - for Teacher Use

*Directions: Use the descriptions in the column labeled "function" to determine a possible human analogy for each Cassini component. Write your human part(s) or human need (s) in the blank column at the right.*

| Cassini Component | Function Human Analogy | |
|---|---|---|
| Spacecraft Bus | The bus is the core structure (or framework) to which spacecraft components are attached. This is made out of aluminum, the same metal used in soft drink cans. | Body/Torso/Skeleton |
| Orientation Thrusters | These are small rocket thrusters (not the main engines) that are used for delicate maneuvers that rotate the spacecraft. This is useful for aiming instruments and pointing the antennae toward Earth | Dancing feet or legs |
| Main Engines | Rocket motors provide thrust for moving the spacecraft in a particular direction or for braking maneuvers. | Walking/runnimg feet or legs |
| RTG's | Radioisotope Thermoelectric Generators (RTG's) are the source of energy for Cassini's instruments and transmitters. RTG's convert nuclear energy to electrical energy. RTG's are not used for propulsion. | Food and drink |
| Spacecraft Cameras | Cameras and other science instruments "see" radio waves, infrared, visible, and ultra violet light emitted or reflected by Saturn and its rings and moons. | Eyes |
| RPW's | The radio and plasma wave science instrument "listens" to different aspects of the environment around Cassini. | Ears |
| Cosmic Dust Analyzer | The dust analyzer will sense dust particles that come into direct contact with the instrument. | Hands/Tongue/Nose |
| Magnetometer Boom | This is an 11-meter-long "arm" extending from the spacecraft. There are instruments in the middle and on the end of the arm that are used to detect and measure magnetic fields. | Extended Arm |
| High/Low Gain Antennae | Receivers and transmitters are used for communication between the spacecraft and Earth-based controllers. The antennae "hear" and "speak" for the spacecraft. | Ears listening and mouth talking on the phone |
| Computers | Computers manage a variety of intelligent functions such as navigation and propulsion, storing information from scientific instruments, and sending information to Earth. There are over 40 different computers on Cassini. | Brain |
| Huygens Probe | This probe will be released from the "mother" spacecraft probe to descend through Titan's atmosphere to gather data on this mysterious moon of Saturn. | Baby |

| |
|---|
| **Science Benchmark: 06 :03**<br>The solar system consists of planets, moons, and other smaller objects including asteroids and comets that orbit the sun. Planets in the solar system differ in terms of their distance from the sun, number of moons, size, composition, and ability to sustain life. Every object exerts gravitational force on every other object depending on the mass of the objects and the distance between them. The sun's gravitational pull holds Earth and other planets in orbit. As Earth's gravitational force holds the moon in orbit. |
| **Standard 03:**<br>Students will understand the relationship and attributes of objects in the solar system.<br>**Objective 3:**<br>Describe the forces that keep objects in orbit in the solar system. |

Activity 4: Gravity

**Intended Learning Outcomes:**

1-Use science process and thinking skills
2-Manifest scientific attitudes and interests
3-Understand science concepts and principles
4-Communicate effectively using science language and reasoning

Teacher Background:

Any object with mass has "gravity." Gravitational force mutually attracts all objects in the universe. Earth's gravity attracts, or pulls us towards it. We also pull Earth towards us. Because Earth is so much more massive than we are, Earth has a greater gravitational force and we are attracted to it. Our mass is so small that our gravitational force is miniscule. An object's gravitational force is dependent upon its mass. Earth is more massive than the moon, but the gravity of each affects the other. Earth's gravity pulls the moon towards it as the moon moves around Earth. In this way, the moon orbits Earth. The moon's gravity causes tides on Earth. They both attract each other, but Earth is more massive, which makes the gravitational force of Earth greater than that of the moon. So, if we were to compare our weight on the moon with our weight on Earth, it would be different. The weight of an object on any planet depends on the gravitational force of the planet attracting the object. The mass of the object, however, always remains the same (i.e. the amount of "stuff" (mass) something is made up of does not magically change). So, the weight of an object on Earth would be different than the weight of the same object on another planet. Since the gravitational force or surface gravity of each planet has been determined, we can calculate our weight on other "worlds."

**Materials:**

- *sturdy* empty cereal boxes • 1 box with the cereal in it and the manufacturer's weight of the box written on the front
- 6-12 pounds of rocks, sand or dirt (depending on the number of objects you wish to compare)
- accurate scale to measure the rocks or dirt

**Invitation to Learn:**

Talk to the students about gravity. Gravity is a force that pulls us towards the center of Earth. Ask them if the moon has the same gravity as Earth. Why not? The moon is less massive than Earth (and has a different surface gravity). Does that mean that objects would weigh less on the moon? Yes! The moon's gravity is about 1/6 of Earth's. This means if a person weighs 120 pounds on Earth he/she weighs only 20 pounds on the moon. Have the students figure out how much they would weigh on the moon by dividing their weight on Earth by 6.

**Instructional Procedures:**

1. Determine the number of objects in the Solar System with which you would like to do weight comparisons and obtain the same number of boxes.
2. Find the weight written on the full box. This is the number you will need to multiply by every other planet's surface gravity to determine how much that same full box on Earth would weigh on the different planets.
3. Using the solar system fact sheet, find the Surface Gravity measurements (9 boxes down from the top of the chart) for the planets you have chosen. Multiply the cereal box weight and the Surface Gravity measurement to find how much the cereal box would weigh on that planet. For instance, a Grape Nuts box weighs approximately 2 pounds. Jupiter has a surface gravity of 2.53. Multiplying 2*2.53, we get 5.06. On Jupiter, the same Grape Nuts box would weigh 5.06 pounds. 4. Students can do all the multiplication and then measure out the correct amount of sand, dirt, or rocks and dump it into an empty box. Label the box.
5. Students can take turns lifting each labeled box, along with the unused box still full of cereal to compare the weight on other worlds. 6. Students can figure out their own weight on other worlds using the same procedure.

**Possible Extension/Adaptations/Integration:**

Writing Integration:

Have students explain in their own words why the moon cannot have an atmosphere.

**Assessment Suggestion:**

**Additional Resources:**